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A DIVISION OF

FLIGHTEX FABRICS INC.

CAMBRIDGE, MASS.

EVERETT, MASS.

PRODUCT PROCESS *Engineering*

REPORT NO.s 9-8-50G-1
10-8-50G-1

MONTHLY PROGRESS REPORT

ENGINEERING PROGRAM FOR THE

DEVELOPMENT OF A LIGHTWEIGHT

ANTI-TANK ROCKET

FOR THE PERIOD

MONTHS OF SEPTEMBER AND OCTOBER 1958

CONTRACT NO. RD-142

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HESSE - EASTERN DIVISION

FLIGHTEX FABRICS, INC.

PROGRESS REPORTS #13 & 14

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

SEPTEMBER AND OCTOBER 1958

CONTRACT NO. RD-142

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WORK DONE DURING THE MONTHS OF SEPTEMBER AND OCTOBER 1958

SYSTEM EVALUATION PROGRAM

Orders have been placed for the bulk of final components. A review of some launcher drawings is under way. Some problems have been encountered in the procurement of HEAT heads and fuze components. Tests have been conducted with final complete systems.

MOTOR DEVELOPMENT PROGRAM

Interior Ballistics

The following table shows the result of 5 more cold static time-pressure curves obtained at - 30°:

Rd. No.	Vert. Cal. v/cm	Horiz. Cal. ms/cm	Curve Peak cm	Peak Pres. psi	10% B Time m sec.	10% B Time inches	P.T. Integral	Pres. Area Sq.in.	Mean Pres. psi
1	.2	10	2.0	3305	30	.485	654	.07	1525.
2	.2	10	2.1	3470	24	.375	648	.06	1620.
3	.2	10	1.9	3140	26	.422	619	.065	1550.
4	.2	10	2.0	3305	26	.422	652	.065	1635.
5	.2	10	2.9	4790	22	.344	653	.06	1785.

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All rounds show burning time in excess of 20 milliseconds. However, with the exception of Round No.1, the burning times would still be acceptable since the tail end of the burning occurs at a very low rate. It is entirely possible that with the obscure type of motor design chosen an ideal situation can never be accomplished in cold rounds as far as out-of-launcher burning is concerned. In observing the high-speed photographs of Round Nos. 306 through 313, a small whisp of burning can be observed outside the launcher in most of the cold rounds. However, it appears to be very narrow, and none of it reaches beyond the O. D. of the launcher. A program of using witness sheets on cold rounds will show whether out-of-launcher burning is going to be a hazard to the gunner. It must also be pointed out that cold tests are being conducted at a temperature of - 30°, which is 10° below the stipulated temperature extreme.

Accuracy and Ignition

Three accuracy tests were conducted during the September-October period:

1. Test conducted on October 30 (Round Nos. 306 to 313).

This was the first test using complete systems for each round fired. Some mechanical difficulties were experienced with the launcher assemblies. This could be partly explained by the fact that all launcher components were made for the 1/8" wall launcher tubes. The tubes available for the test still had the .1" wall. The difference was made up by the use of plastic tape. This resulted in a certain loss of rigidity. In addition

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to this, experience in assembling systems now seems to indicate that some minor changes have to be made in order to increase the rigidity and facilitate assembly. The result of small movements of the bands around the launchers was a change in location between the trigger linkage and the firing lever which is used to cock and release the igniter-firing pin. This caused some rounds not to initiate their igniter until this condition was corrected. The following is a tabulation of the test results:

Round No.	Temperature Cond. To	Vel. (F/S)	Target Hit	Out-of-Launcher Burning	Comments
306	+130	293	Center Left	None	
307	+130	286	" Right	None	Some delay
308	+130	293	" High	None	
309	- 30	286	" Over	Yes	Slight thin stream of burning outside launcher for 3 feet
310	- 30	267	" Over	Yes	" " "
311	- 30	267	" High	Yes	" " "
312	- 30	286	" High	Yes	" " "
313	+130	308	Left High	None	

A small amount of burning outside the launcher can be observed on the motion picture record of the cold rounds. However, the amount of outside burning is extremely small, and the stream of hot gases appears to be considerably thinner than the diameter of the launcher and to disappear completely within it. As mentioned in the Interior Ballistics Section of this

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report, this may be inherent in this design and may not affect the gunner to any noticeable degree. It is planned to conduct tests with witness sheets to determine what the effects on the gunner may be.

Due to the difficulties encountered with the launcher, a group of hits on the target which would give some indication of the accuracy of the round was not obtained during this test. It must be noted that launcher sights were used, and each round was aimed at the center of the target. It was decided to run one or two more accuracy tests without conditioning in order to establish proper functioning of the over-all system and to obtain a group on the target. It is then planned to run further accuracy tests which would establish the accuracy that can be expected.

2. Accuracy test run on October 17 (Round Nos. 317 to 326).

This time all systems worked satisfactorily, and a group of 2-feet horizontal and 4-feet vertical dispersion was obtained on the target:

Accuracy test - October 17, 1958.
Temperature - Ambient (60° - 70°F).
All rounds within a rectangle of 2 feet (horizontal) and 3 1/2 feet (vertical).
Launcher elevated 105 mils.
Sights aimed at center of group on target.
Target - 100 yards.
.1 wall launcher. Test of complete system

Round No.	Velocity (F/S)	Fuze	Fuze Function	Comments
317	286	Mod III	Yes	
318	278	"	"	
319	291	Dummy		
320	286	"		

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Round No.	Velocity (F/S)	Fuze	Fuze Function	Comments
321	286	Dummy		
322	286	"		Slight instability middle of flight path
323	291	"		
324	286	"		
325	288	"		
326	285	"		

3. Test of the same nature conducted on October 23 (Round Nos. 327 to 338).

The following is a tabulation of this test:

100 yard accuracy test - October 23, 1958.
Temperature - Ambient (50° - 60°).
For target pattern, see chart next page.
Launcher elevated 100 mils for Round No. 327, 107 mils thereafter.
Sights aimed at approximate center of target group.

Round No.	Velocity (F/S)	Fuze	Fuze Function	Comments
327	258	Mod III	Yes	Aimed low, went under target, not included in group
328	278	"	"	Changed sighting point to high right of target from here on. All rds. within group next page.
329	286	Dummy		
330	286			

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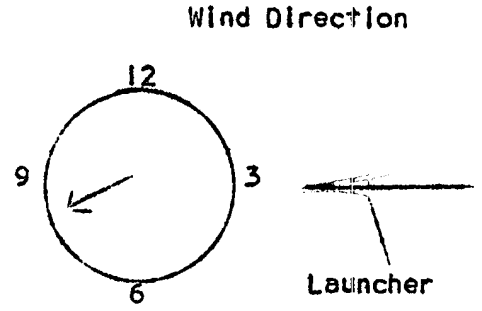
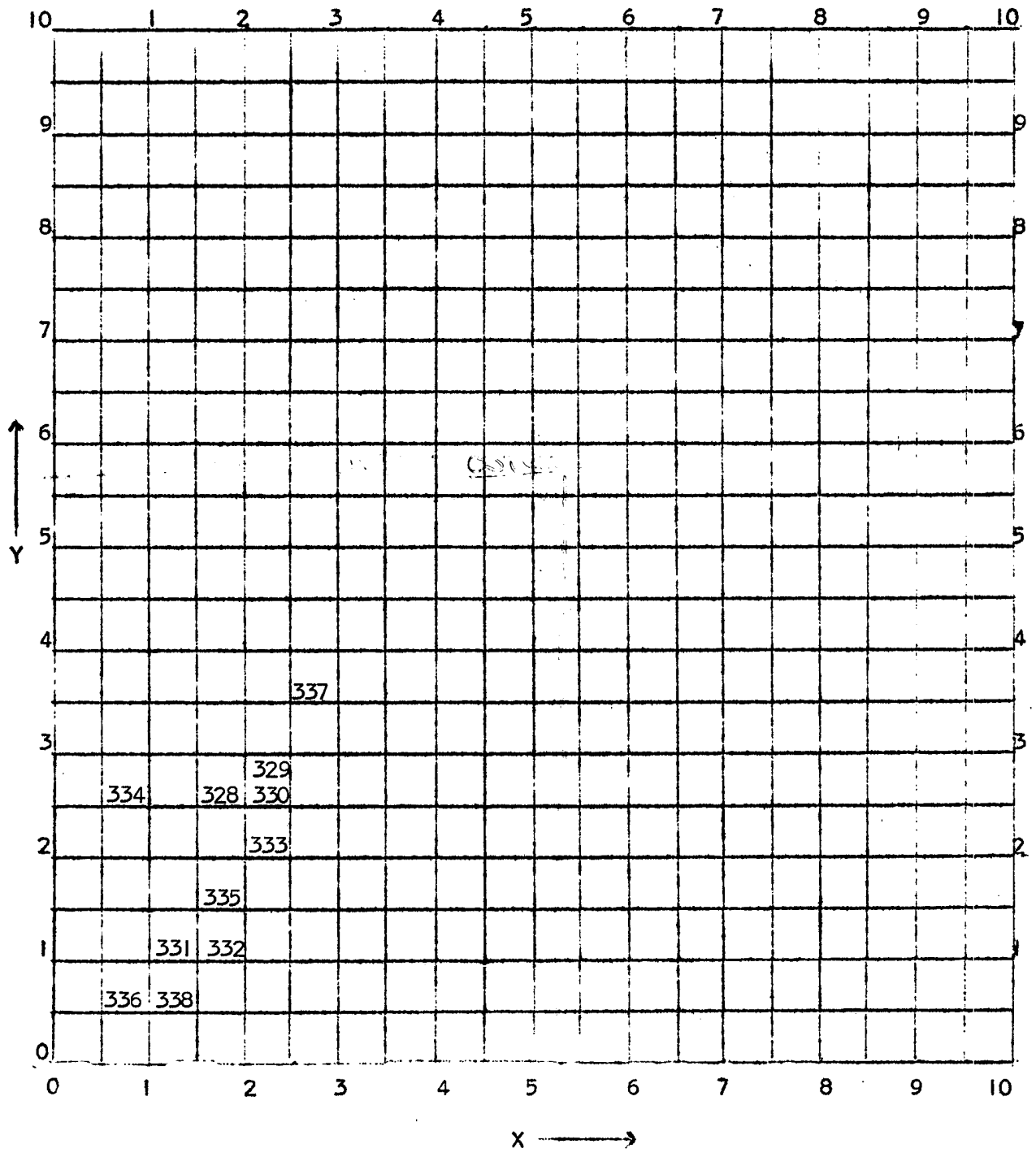
TARGET ACCURACY TEST

DATE:

Wind: Approximate Velocity 5-10 MPH

Approximate Direction





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TARGET ACCURACY TEST

(Continued)

Round No.	X	Y
337	3	4
334	1	3
328	2	3
329	2.5	3
330	2.5	3
333	2.5	2.5
335	2	2
331	1.5	1.5
332	2	1.5
336	1	1
338	1.5	1
Σy_{11}	21.5	25.5

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Round No.	Velocity (F/S)	Fuze	Fuze Function	Comments
331				No picture taken - OK
332 to 336				" "
337	291			Slight afterburn at 10 feet from launcher. No out-of-launcher burning
338				No picture taken - OK

The target accuracy chart on the next page shows the target hits obtained in the second test. It is planned to conduct a firing test during November when a group of hot and cold rounds will be fired at the target, and the group obtained will be evaluated for standard deviation.

In conducting a dynamic penetration test on October 20, 22 and 23, it was noticed that with the sights set at 100 meters it would be necessary to aim considerably under the target for a short range, and it therefore has been decided to change the sights in order to zero the weapon in at 50 meters.

Procurement of Motor Parts

Considerable delay has been experienced with Harvey Machine who have at last confirmed the fact that they are now going to start tooling and fabrication of the 500 motors ordered from them in early June. We have a delivery promise of mid-November.

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Tail Fins

The final quantity of tail fins has been received, and 200 sets of components have been surface finished. The tail fins appear to be working out extremely well, and this part of the project may be considered as complete.

Propellant

A considerable amount of additional cost and time delay in the program is being experienced due to the fact that no propellant has as yet been received from Radford Arsenal. All propellant used in the tests since the change in interior ballistics had to be machined from the original lot of propellant. The latest information in our possession indicates that propellant will be shipped from Radford the first of November. As soon as this material has been received at our Range, it will be necessary to run through a short program of static firings in order to determine whether the propellant shows any difference in performance characteristics to the machined propellant.

WARHEAD DEVELOPMENT PROGRAM

Both static and dynamic tests were conducted with the final HEAT head design during the period. The tabulation of the static firing conducted on September 24 will be found on the following page.

The average penetration shown in the static test is 11.08".

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RESULTS OF STATIC PENETRATION TEST - 24 SEPTEMBER 1958

Density	Double Jet in Plate	Plug in Plate No.	Penetration
1.69	No. 3	8	8 1/2"
1.70	No. 5 (small)	5,6,7	12"
1.69	0	7,8,9, 11,12,13	13 5/8"
1.69	1 & 3	2,8,9,10	10 1/4"
1.69	9 (small)	6,7,8,9,10	10"
1.65	4	11 & 13	12 3/4"
1.69	1,2,3,4,5	4,5,6,7	8"
1.70	1,2,3,4,5,6	4,5,6,7	9 3/4"
1.66	1	5,6,7,10	12 3/4"
1.69	0	1,2,8,9,10	13 1/4"

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Stand-off used was 3". It is safe to assume that dynamic firings would produce similar results. It must, however, be pointed out that a number of conditions exist in dynamic rounds which are not duplicated in the static firings:

1. The stand-off obtained for each round is a result of the functioning time of the fuze and of the amount the ogive crushes up. The ogive has been constructed in such a way that crush-up will be approximately 1/4 of an inch more than optimum at 40 feet from the launcher. It is then assumed that at a distance of 50 or 100 meters from the launcher the crush-up will be approximately correct since some reduction in velocity has taken place after travelling 50 to 100 meters. The difference in velocity has not yet been established in this project. However, it is known from past experience on other projects that it is relatively slight, and therefore, a 1/4 of an inch additional crush-up at 40 feet is likely to be a sound approximation based on experience.

2. The attitude of the round cannot be predicted with any accuracy, and it must be assumed that a perfectly vertical attitude will be the exception rather than the rule even at close range. A deviation from a square attitude by even a few degrees will cause a reduction in penetration since the copper slug will enter the armor plate at an angle.

3. The possibility of some deterioration in the charge during the time when the ogive is being crushed up should be taken into consideration. Whilst it is true that the head design will cause the forces acting on the head when it hits the target to travel through the steel parts of the head and on into the motor, it must nevertheless be pointed out that the

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charge is subject to deceleration when hitting the target. As far as is known to the writer, rockets with mechanical fuzes have a very bad record in their actual penetration performance for this reason. A dynamic test with 8 rounds using fuze Model No. 3 was conducted on October 22 and 23. The following is a tabulation of the test results:

Densities of all heads - 1.68 - 1.7 grams per cc.

Fuze Model No. III. Range 40 feet.

Two 3" armor plates with 1/4" gap between plates.

Round No.	Penetration Yes	Penetration No	Comments
339	X		
340		X	
341	X		
342		X	
343		X	
344		X	
345	X		
346			Fired first 10/22; booster not initiated; hole in plate between booster and charge was enlarged in all other rounds after this.

When firing the first round, the fuze was observed to function on the target, but the HE charge was not initiated. Upon disassembling the

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head, it was found that the detonator had only scorched the tetryl booster. The barrier used between the fuze and the explosive components of the round consisted of an aluminum disc .031" thick with a 1/16" diameter hole in line with the detonator when the fuze is in an armed position. Upon discovering the situation, all remaining HEAT rounds were disassembled, and the size of the hole increased to 1/4". No further difficulties were experienced in this respect. The barrier between fuze and explosive components will be changed, and a .005 steel disc without a hole will be substituted for the aluminum disc. Further dynamic tests will have to be conducted under more controlled conditions. The two 3" armor plates used during the test have a separation of a 1/4" between each other. It has been found in the past that a gap between plates penetrated by a HEAT head causes a reduction of penetration of up to 30 per cent. It must therefore be stated that the results of this penetration test are inconclusive. The 4 rounds which penetrated both 3" plates show exit holes of a size and configuration which leads one to believe that penetration would have been at least another 3".

It is planned to erect witness screens at different distances from the target in order to find out what size fragments can be expected. The evaluation of these tests will be used to determine the closest range at which it will still be safe to use the weapon.

FUZE DEVELOPMENT PROGRAM

Considerable delay has been experienced in the fuze program due to

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the fact that parts received from our subcontractor had to be rejected several times before we could use them for any testing. Components were not available until the second week in October. At that time 10 fuzes, Model No. 4, were assembled and statically tested for set-back and arming with a drop of 3 feet. The results of these tests were satisfactory as far as set-back and fuze sensitivity was concerned. However, half the fuzes so tested failed to arm. Upon further evaluation of the test results and the results of the drop test conducted in August, it was decided to incorporate a torque spring in the fuze design to help arm the rotor. The necessary drawings have been completed and the torque springs as well as the minor modifications to the fuze housings ordered. It is expected that functioning tests will commence early in November. Reference is made to page 9 of the August Report. Under Fuze Development Program a statement is made that "Some modifications were made to the drawings to eliminate this condition and a set of 50 components was ordered in the middle of August". It appears that the modifications made at the time were insufficient to assure reliable operation of the rotor.

In order to cause no delay in the rest of the program, Model No. 3 fuzes were assembled for the dynamic penetration test. All fuzes functioned properly. In addition to this, 4 fuzes, Model No. 3, were used in accuracy rounds fired during the month (Round Nos. 317, 318, 327 and 328). All fuzes functioned upon impact. Round Nos. 318 and 328 may be considered as graze functions.

The importance of assuring good graze sensitivity is sufficient to warrant the continuation of tests and engineering on fuze Model No. 4.

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However, it may be stated that fuze Model No. 3 could be used in case undue trouble is experienced with Model No. 4. This would give the weapon a fuze which fulfills the original conditions as discussed when the contract started, i.e., that the requirements on any components of the systems were not to be considered as having to be as stringent as a final military item manufactured in this country. In fact, this lesser reliability may be interpretated as adding to the sterility of the item.

All safety mechanisms worked properly, and it may be assumed that little, if any, more trouble will be experienced in this direction.

FUTURE PROGRAM

The following program will have to be carried out on the fuze:

1. Functioning Tests
2. Graze Sensitivity Tests
3. Arming Tests
4. Detonator Safety Tests
5. Jumble and Jolt Tests

A mock-up of the system containing only a portion of the inner sleeve, head, launcher, etc., will be constructed in order to run jumble and jolt tests with the fuze.

LAUNCHER DEVELOPMENT PROGRAM

Three objectives essential to finalizing the launcher were accomplished during the month:

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1. Static and dynamic launcher tests were conducted, and a launcher tube has been chosen as the final design.

2. Recoil tests with the launcher were conducted, and an approximate value for the expected recoil has been obtained.

3. The sights have been set at 100 yards, and with the assembly and dynamic use of 20 systems, all minor modifications required to freeze the design have been determined, and work on such modifications has been started.

Recoil

A launcher recoil test was conducted 25 October (Round Nos. 291 to 304). The following is a tabulation of this test:

Round No.	Impulse Ft/Lbs. First Foot Travel	Impulse Ft/Lbs. Third Foot Travel	Comments
291	1.06	.867	
292	1.11	.888	Afterburn outside of launcher
293			No data available
294	1.1	1.01 (Second Foot)	Hard to evaluate
295	.99	.918	
296	.75	.705	
297	.705	.439	
298	1.16	.905	

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Round No.	Impulse Ft/Lbs. First Foot Travel	Impulse Ft/Lbs. Third Foot Travel	Comments
300	1.158	1.04	
301	.895	.701	
302			
303	1.39		Third Foot not available
304	.862		Third foot not available

Average impulse over first foot travel - 1.08 (12 rounds)

Average impulse over third foot travel - .875

Since the value for the MI rifle is approximately 10-foot pounds of recoil on the shoulder of the rifleman, it may be stated that no problem should be encountered in connection with recoil with the values obtained in this test. Some difficulties were experienced in evaluating the results. However, it appears to be sufficiently conclusive to warrant conducting a shoulder firing test as soon as sufficient extruded motors are available with a sufficient number of firings without blow-ups to warrant this procedure.

Sights

During the accuracy tests on September 30 and October 7 and 23, launcher sights were used to zero in on the 100 meter target. The present sight configuration will make the rocket hit the center of a target at 100 yards when the sights are aimed at the center of the target. It has, however,

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been found that this will cause some problems when aiming at close targets. It would necessitate aiming under the target at close ranges. It was therefore decided to make a change in the sights and to aim them at a 50 meter target. The correct aiming points at 100 meter targets and point blank targets will have to be determined in further tests. This procedure does not appear to present any great problem as far as procuring final components is concerned since the front sight can be left longer in the components ordered and the correct length as soon as this has been established.

Launcher Assembly

Some minor difficulties were experienced in the assembly of the launchers, and methods of eliminating them have been found. It appears to be indicated to combine the two bands, which now hold the trigger housing, into one wide band, in order to increase the rigidity of the assembly and to facilitate line-up of the trigger components. Another minor change in the small screws which secure the launcher bands to the launcher tube is being made. It consists in eliminating the elastic stop nuts now in use and substituting small screws machine parts which will fulfill a similar purpose but which will serve to obscure the design. Small holes will be drilled through the launcher wall on assembly, and instead of the small set screws used with the elastic stop nuts, pins will be inserted through the holding members. The pins will then be staked in position. This will improve the rigidity of the package, add to its neatness, facilitate the design and eliminate non-sterile elastic stop nuts.

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Tests of Launchers Under Motor Failure Conditions

Round Nos. 314, 315 and 316 were tested for determining what the reaction of various types of launcher tubes would be when a motor failure occurs. Launchers with rockets were electrically fired after the wall thickness of the rocket had been reduced in one area to the point where a failure would occur at close to maximum operating pressure. The results of this test were as follows: All tubes tested ruptured. The ruptures were very similar in nature. The following types of tubes were tested: .1" wall tube obtained from Babbitt Pipe with a burst strength of 1400 psi; .125" wall paper tubes obtained from Richardson Company with a burst strength of 1700 psi. It was hoped that the strongest tubes would not rupture when a motor failure occurs. This would be desirable but is not considered essential. It is felt that the program would be delayed too much if further investigation in this matter were conducted, and it is therefore felt that the present approach, namely, to make the motor body as safe as possible, will have to be sufficient.

Launcher Strength Test

A number of different launcher tubes have been tested for strength, and the following is a tabulation of the results:

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STATIC LAUNCHER TEST

Date	Supplier	Type	Code No.	Results (Burst)	Comments
9/2/58	Richardson	Wound Cloth		850 psi	.100 Wall
9/2/58	"	" "		900 psi	.100 Wall
9/2/58	"	Wound Paper		1200 psi	.125 Wall
9/2/58	"	" "		150 psi	.125 Wall-rocket had been fired from this launcher-possible cause for this low bursting pressure.
9/5/58	General Elec.	" "		1000 psi	.100 Wall
9/5/58	"			1000 psi	.100 Wall
9/12/58	Babbitt Pipe	Spiral Wound Paper	3C-9C	1450 psi	.100 Wall
9/12/58	"	" "	4VH-8B	1200 psi	.100 Wall-Tube was pumped up to 800 psi and brought down to zero. Then pumped up to its bursting pres.
9/12/58	"	" "	4VH-8B	1350 psi	.100 Wall
9/12/58	"	Wound Paper	.00275-1	1700 psi	.125 Wall
9/12/58	Richardson	" "	.00275-1	1650 psi	.125 Wall
9/25/58	"	" "	.00275-1	1500 psi	.125 Wall
9/25/58	"	" "	.00275-1	1575 psi	.125 Wall
9/15/58	"	Wound Cloth		1000 psi	.100 Wall-Tube used in one firing test
9/15/58	"	" "		950 psi	.100 Wall-Tube used in one firing test

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Date	Supplier	Type	Code No.	Results (Burst)	Comments
9/15/58	Richardson	Wound Cloth		875 psi	.100 Wall-Tube used in one firing test
9/15/58	Gen. Elec.	Wound Paper	1846	200 psi	.125 Wall
9/15/58	"	" "	1846	825 psi	.125 Wall
9/15/58	"	" "	1846	800 psi	.125 Wall
9/15/58	Babbitt Pipe	Spiral Wound Paper	IC-7UC-5B	1300 psi	.100 Wall
9/15/58	"	" "	"		.100 Wall-Pumped up to 1,000 lbs. eight times-Up to 1,100 lbs. two times, Up to 1,200 lbs. two times, Up to 1,300 lbs. once. Pumped up to 1,400 - burst.
9/16/58	Richardson	Wound Cloth	T889	1300 psi	.125 Wall

The Richardson cloth tube with 1/8 wall has been chosen for the following reasons:

1. Their delivery schedules are the only reliable ones.

2. The strongest tube which is not excessively brittle of all tubes tested. It has to be noted that in spite of the fact that some paper tubes show very high burst strength characteristics those tubes are invariably of a very brittle nature and not considered suitable for this reason.

Twenty tubes have been received from Richardson, of which one was subjected to a hydrostatic test to determine its burst strength. The tube burst at a pressure of 1300 psi. All other tubes were then subjected to a

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900 psi test. The results of this test were as follows: All tubes stood up to the 900 psi test with the exception of two. One of those burst at 650 psi and the other at 875 psi. Upon examining the ruptured tubes, a fold was found in the lap, i.e. when the cloth was wound onto the mandrel, the leading edge had formed a crinkle. This causes an uneven line inside the launcher tube which can be visually observed. The break in both tubes occurred approximately along that uneven line. Breaks in good tubes are perfectly straight. In discussing this condition with the manufacturer, we were given his assurance that this condition will be eliminated in the future. In addition to this, a 900 psi test is probably sufficient to assure us of safe tubes when firing. The 17 tubes remaining from these static tests were used during tests in October without any failures. It is felt that the launcher tube program is almost complete at this point. Further testing will show whether any problem areas with the launcher tube still exist. The concept of using small holes for indexing the trigger components and the sights will have to be checked out by dynamic tests. There does not appear to be any reason why this should cause a problem with the cloth tube. Tests at extremes of temperature using complete systems will further check out the launcher tube.

Finalizing of Drawings and Procurement

The experience gained in the assembly of the launchers used during the reporting period is being put to use in effecting minor changes. A very thorough checking of launcher drawings is also in process. In the meantime

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all components are being priced, and some 60 per cent of all launcher components are being manufactured at our own model shop at the present time. It is expected that all final launcher components will be available during December for Assembly in December and January. Work has also been started on the design of a launcher assembly fixture.

Evaluated vs. costs expended for the months:

September:	October:
$6,395.64	$11,470.70

Charles B. Weeks
General Manager

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